

**DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Office of Flexible Pavement Materials
5900 Folsom Blvd.
Sacramento, California 95819-4612**



Lab Procedure – LLP-AC1 SAMPLE PREPARATION AND TESTING FOR LA-710 — LONG-LIFE ASPHALT CONCRETE

General

Long-Life Asphalt Concrete Pavements are unique in their design, specifications and construction. Essentially, these projects are designed in a manner consistent with the mechanistic-empirical approach to pavement design, in which the structural section is designed taking into account the performance characteristics of the asphalt concrete, the anticipated loading for the life of the pavement and the anticipated modes of failure, typically rutting (in the short-term) and fatigue (in the long-term).

The asphalt concrete pavement must be constructed using an asphalt concrete mixture in which the performance characteristics (shear and fatigue) control the mix design. The producer must assemble an aggregate/binder mix that will meet the required performance characteristics (shear and fatigue); and then define that mix using the traditional attributes of gradings of the aggregates, asphalt content, stability, voids and compaction. These qualities will be used during production and placement for quality control measures and, ultimately, for quality assurance. Background research that was conducted on mix design for the I-710 is detailed in Technical Memorandum UCPRC-TM-1999-2, "Mix Design and Analysis and Structural Section Design for Full depth Pavement for Interstate 710".

Shear is determined from the Superpave Shear Test and Fatigue from the Flexural Beam Test. The following testing shall be followed:

1. Determine an initial trial mix for proposed aggregate and binder
2. Prepare at least three samples for each asphalt content over a range of binder contents at the required air voids:
 - 3.0 ± 0.3 percent for shear, and
 - 6.0 ± 0.3 percent for fatigue.

Note: Project specifications require performance within the production tolerance of 0.3 percent on asphalt content. It is advisable that the performance be examined over the range at 0.3 percent intervals.
3. Test samples for shear and fatigue.
4. Analyze test data.
5. Adjust aggregate gradings or asphalt content if necessary and retest until the requirements for shear and fatigue are met.
6. Test mix at the selected gradings and asphalt content to determine the stability and air voids target values.

TEST METHODS

1. SHEAR TESTING

Shear testing shall be carried out according to AASHTO T320-03¹, “Standard Method of Test for Determining the Permanent Shear Strain and Stiffness of Asphalt Mixtures Using the Superpave Shear Tester”, with the following modifications:

Only Procedure C, “Repeated Shear Test at Constant Height,” is required.

Also:

- 2.1 - Replace T312 with PP3-94. “Standard Practice for Preparing Hot Mix Asphalt Specimens By Means of the Rolling Wheel Compactor.”
Delete T166, “Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens.”
Add T275, “Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens.” Substitute a thin adherent plastic wrap (Parafilm “M”) for the paraffin coating specified.
- 6.2.4 - Replace with:
“After the short-term conditioning is complete, the asphalt concrete mixture specimen should be compacted to the appropriate percentage of air voids using PP3-94. For the repeated shear test and associated analysis, the percentage air voids in the test specimen (which may be cut to the appropriate dimensions of 150 mm diameter and 50 mm height) should be 3.0 ± 0.3 percent. For the simple shear and shear frequency sweep tests, the percentage of air voids in the test specimen (which may be cut to the appropriate dimensions of 150 mm diameter and 50 mm height) should be 6.0 ± 0.3 percent. To achieve these target air voids, it may be necessary to compact the specimen (before cutting) to a slightly higher percentage of air voids.”
- 6.2.6 - Replace with:
“Determine the percentage of air voids in the test specimens in accordance with T209, T269 and T275. Substitute a thin adherent plastic wrap (Parafilm “M”) for the paraffin coating specified. Determine the height of the test specimens in accordance with ASTM D3549.”
- 6.3.2 - Replace with:
“Determine the percentage of air voids in the test specimens in accordance with T209, T269 and T275. Substitute a thin adherent plastic wrap (Parafilm “M”) for the paraffin coating specified. Determine the height of the test specimens in accordance with ASTM D3549.”

¹ AASHTO T320-03, “Standard Method of Test for Determining the Permanent Shear Strain and Stiffness of Asphalt Mixtures Using the Superpave Shear Tester” is the most recent revision of AASHTO TP7-94, “Standard Test Method for Determining the Permanent Deformation and Fatigue Cracking Characteristics of Hot Mix Asphalt Using the Simple Shear Test (SST) Device” referenced in the project special provisions.

Sample Preparation and Testing for LA-710 — Long-Life Asphalt Concrete

- 6.4.2 - Replace with:
 “Determine the percentage of air voids in the test specimens in accordance with T209, T269 and T275. Substitute a thin adherent plastic wrap (Parafilm “M”) for the paraffin coating specified. Determine the height of the test specimens in accordance with ASTM D3549.”
- 6.5.3 - Replace with:
 “Apply a thin coating of the adhesive to the top of the test specimen and to the bottom platen. Orientate the specimen such that it is parallel to the direction of compaction and shear stresses and strains will be applied in the same direction as the compaction device (rolling wheel) or traffic. Center the test specimen on the bottom platen and lower the top platen onto the specimen. Rotate the specimen slightly back and forth to ensure good bonding, ensuring that the original orientation position is maintained.”
- 8.7.2 - Replace with:
 “Record the axial and shear deformations (from the LVDTs) and axial and shear loads. Record at minimum rate of 50 data points per second during the intervals specified in Table 2.

Table 2 - Required Interval Ranges for Recording Data for Procedure B and C

Data	Cycles
1 through 10	2749 through 2751
19 through 21	2999 through 3001
29 through 31	3249 through 3251
49 through 51	3499 through 3501
79 through 81	3749 through 3751
99 through 101	3999 through 4001
199 through 201	4249 through 4251
299 through 301	4499 through 4501
399 through 401	4749 through 4751
499 through 501	4999 through 5001
599 through 601	5499 through 5501
799 through 801	5999 through 6001
999 through 1001	6499 through 6501
1199 through 1201	6999 through 7001
1399 through 1401	7499 through 7501
1599 through 1601	7999 through 8001
1799 through 1801	8499 through 8501
1999 through 2001	8999 through 9001
2249 through 2251	9499 through 9501
2499 through 2501	9999 through 10000

- 9.7.2 - Replace with:
 “Continue the test sequence for 10,000 cycles or until the shear LVDT exceeds its range (usually at 2.5 mm or 5 percent shear strain).”

Sample Preparation and Testing for LA-710 — Long-Life Asphalt Concrete

- 9.8 - Replace Note 19 with:
 “The repeated shear test at constant height takes approximately 3 hours to execute from the time the specimen is removed from the conditioning chamber until the test is completed and the specimen is removed from the shear tester.”
- 10.3 - Remove “(nominally 5000 cycles)” from the sentence.
- 10.4 - Add:
 “For tests that do not reach 5 percent permanent shear deformation within 10000 repetitions, the repetitions to 5 percent shear strain must be extrapolated. The extrapolation is done using a straight line approximation based on a log-log plot of repetitions versus permanent shear strain. The following analysis method modifies the data by assuming a zero intercept when no repetitions have been applied:

Apply a 4th - order polynomial approximation (shown below) to the first 10 data points of the test based on the linear data. The y-intercept is then obtained from the equation. This value (a_0) is subtracted from the permanent shear strain. If the waveform is not convex or if a_0 is negative, a 3rd - order polynomial is used. If a_0 is again negative, no adjustment is made to the data.

$$Y = a_0 + a_1x_1 + a_2x_2^2 + a_3x_3^3 + a_4x_4^4$$

The permanent shear strain versus repetitions is graphed on a log-log plot, and the number of repetitions is determined by interpolating from the data. If data extrapolation is necessary to determine the number of repetitions to a given level of shear strain, all the repetitions from the 100th repetition of data are used to estimate the slope (b) and y-intercept (a).

$$Y = aN^b \quad \text{or} \quad (\log Y) = (\log a) + b(\log N)$$

- 11.4.1 - Replace with:
 “For each specimen, report the number of repetitions required to obtain 5 percent permanent shear deformation.”

2. FATIGUE TESTING

Fatigue testing shall be carried out according to AASHTO T321-03²: “Standard Method of Test for Determining the Fatigue Life of Compacted Hot Mix Asphalt Subjected to Repeated Flexural Bending”, with the following modifications:

- 2.1 - Add T275 – “Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens”
- 5.2 - Add: “Use Devcon 10240 5-minute epoxy.”

² AASHTO T321-03, “Standard Method of Test for Determining the Fatigue Life of Compacted Hot Mix Asphalt Subjected to Repeated Flexural Bending” is the most recent revision of AASHTO TP8-94, “Standard Test Method for Determining the Fatigue Life of Compacted Hot Mix Asphalt (HMA) Subjected to Repeated Flexural Bending” referenced in the project special provisions.

Sample Preparation and Testing for LA-710 — Long-Life Asphalt Concrete

- 7.1 - Replace with:
“Laboratory-mixed and Compacted Specimens - Sample asphalt binder in accordance with T40 and sample aggregate in accordance with T2. Prepare three replicate hot-mix asphalt beam specimens sawn from slabs compacted in accordance with PP3.

Note 1 - The type of compaction device may influence the test results

Note 2 - Normally test specimens are compacted using a standard compactive effort. However, the standard compactive effort may not reproduce the air voids of roadway specimens measured according to T269 and/or T275. If specimens are to be compacted to a target air void content, the compactive effort to be used should be determined experimentally.”

- 7.2 - Replace with:
“Plant-mixed Laboratory Compacted Specimens - Obtain HMA samples in accordance with T168. Prepare three replicate hot-mix asphalt beam specimens sawn from slabs compacted in accordance with PP3 (see Notes 1 and 2).”

- 7.4 - Replace with:
 “Saw at 6 mm from both sides of each test specimen to provide smooth, parallel (saw cut) surfaces for mounting the measurement gages. The final required dimensions, after sawing, of the specimens are 380 mm ± 6 mm in length, 50 ± 3 mm in height and 63 ± 3 mm in width.”

- 8.2 - Replace title with: *“Epoxying Nut to Neutral Position on Specimen – ”*

- 8.2 - Replace Figure 2 title with: “Nut Epoxied to Neutral Position on Specimen”

- 8.8 - Replace with: “Set the deflection level (strain level) to the prescribed value.”

- 8.9 - Add:
 “The data collection schedule should be set to collect 20 points evenly distributed between each logarithm cycle from 10 repetitions to 10,000,000 repetitions. Data should also be collected at 4,000,000 repetitions.”

- 9.1.1 - Replace with:
“Maximum Tensile Stress (Pa):

$$\sigma_t = (3aP)/(bh^2)$$

where:

a = space between inside and outside clamps

P = load applied by actuator in Newtons

b = average specimen width in meters

h = average specimen height in meters”

- 9.1.6 - Change units of y-axis in Figure 6 to MPa

Sample Preparation and Testing for LA-710 — Long-Life Asphalt Concrete

9.1.7 - Replace with:

“Initial Stiffness (Pa) - The initial stiffness is determined by plotting stiffness (S) against load cycles (n) and best-fitting the data to an appropriate exponential function, an example of which is shown in Equation 7. Figure 7 presents a typical plot of stiffness versus load cycles. The constant A represents the initial stiffness.

$$S = Ae^{bn}$$

where:

e = natural logarithm to the base e

A = constant

b = constant”

9.1.7 - Change units of y-axis in Figure 7 to MPa

9.1.8 - Delete this paragraph (duplicate of 9.1.7)

9.1.9 - Change to

“Cycles to failure - Failure is defined as the point at which the specimen stiffness is reduced to 50 percent of the initial stiffness. The load cycle at which failure occurs should be interpolated or extrapolated from the test data. For tests in which the stiffness is not reduced by 50 percent after 4 million repetitions, the number of repetitions to 50 percent stiffness reduction is extrapolated using the following method:

1. Plot $\ln(-\ln SR)$ versus $\ln(n)$,
where SR is the stiffness ratio defined as the ratio of stiffness at repetition n over the initial stiffness (50th repetition) and \ln is the natural logarithm.
2. Select the test points between $\ln(n_f)$ and $\ln(n_f) - 2$
where n_f the final repetition, is the minimum interval to obtain the intercept (a) and slope (b) parameters of the following linear regression formulation: $\ln(-\ln SR) = a + b \cdot \ln(n)$.
3. Determine the fatigue life (N_f) using the following equation:

$$N_f = \exp\left(\frac{\ln(-\ln 0.5) - a}{b}\right).$$

An interpolation procedure is applied when the specimen stiffness is reduced to 50 percent of the initial stiffness in less than 4,000,000 repetitions. The following procedure should be used:

1. Prepare a table with load repetitions and SR values, where SR is the stiffness ratio, defined as the ratio of stiffness at repetition n over the initial stiffness (50th repetition).
2. Determine the fatigue life (N_f) using a linear interpolation between two points that have SR values immediately below and above the 0.5.”

10.5 - Replace with: “Report the initial flexural stiffness in mega Pascals (MPa)”

Sample Preparation and Testing for LA-710 — Long-Life Asphalt Concrete

3. ROLLING WHEEL COMPACTION

Asphalt specimens shall be compacted according to AASHTO PP3-94: “Standard Practice for Preparing Hot Mix Asphalt Specimens by Means of the Rolling Wheel Compactor”, with the following modifications:

5.3 - Replace with:

“Oven - a forced-draft electric oven capable of maintaining any selected temperature setting between 100 and 200°C within a tolerance of $\pm 3^\circ\text{C}$ for heating asphalt binder and aggregate.”

8.5 - Replace with: “Spray a mild soapy solution to the base and sides of the mold.”

10.2.5 - Replace with:

“After filling, close all containers tightly and allow to cool to room temperature. Store the asphalt binder at a temperature of $20 \pm 2^\circ\text{C}$ until the scheduled time for preheating prior to mixing. Closing the containers prior to cooling produces a vacuum seal.”

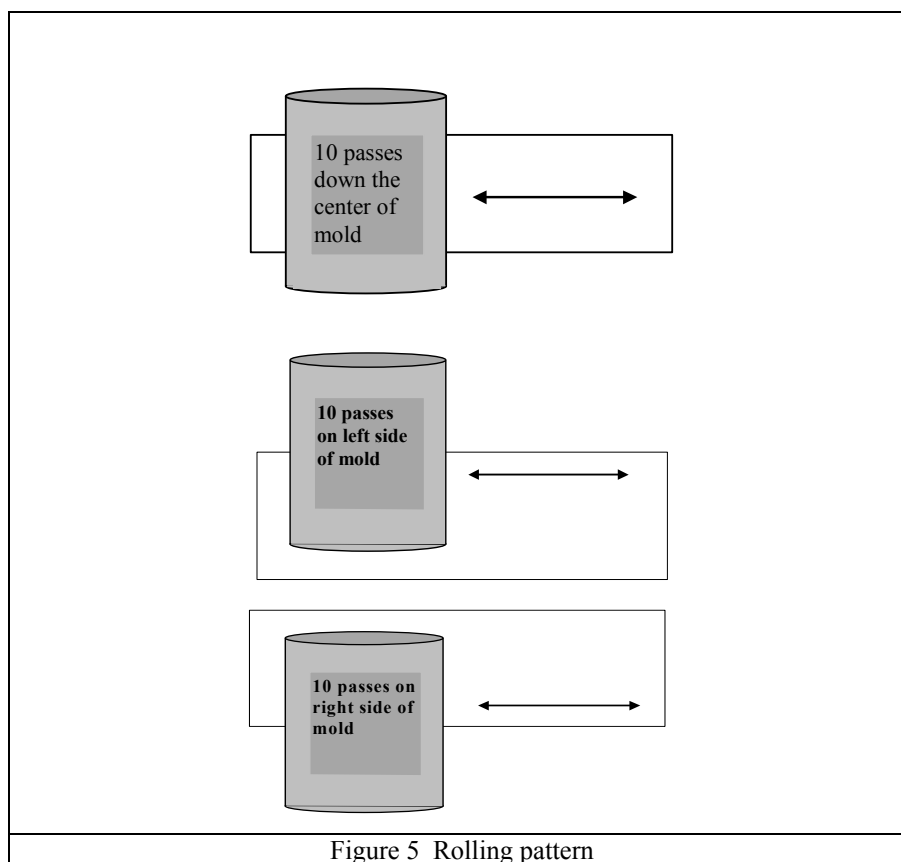
11.4.3 - Replace with:

“Remove a pan of mixture from the oven and place the mix in the center of the mold. Level the mixture using a rake. Avoid any segregation of the mixture or tumbling of the coarse aggregate. Repeat this process until the material required to achieve the target air void content (all of the pre-weighed material) is in the mold. Tamp the mixture with a spade to achieve as level a surface as possible. The tamping pattern should entail 10 tamps along the length of the mold perpendicular to the rolling direction followed by 10 tamps parallel to the rolling direction on alternating sides along the entire length of the mold. A single layer is used in the compaction process.”

11.4.4 - Replace with:

“Apply 10 passes with the roller straddling the mold (Figure 5). One pass is the movement of the wheel in one direction over the entire ingot. When necessary, asphalt adhering to the wheel should be scraped off and replaced in the mold and displaced material on the sides of the mold should be pushed back to the center of the mold with a spade. Apply a second series of 10 passes with the roller on the left half of the mold, a third series of 10 passes with the roller straddling the mold, a fourth series of 10 passes on the right half of the mold and a fifth series of 10 passes with the roller straddling the center of the mold. Compaction is complete when the roller rides on the steel of the mold frame for the entire length of the mold. If complete compaction has not been achieved after 50 passes the above pattern should be repeated. When compacting, each pass of the roller must extend from the ramp to the platform in a continuous motion, with no stops on the mixture.”

Sample Preparation and Testing for LA-710 — Long-Life Asphalt Concrete



11.6 - Replace with:

“After the slab is completely cooled, chalk arrows on the surface indicating the direction of the rolling wheel in order that specimens can be correctly oriented in later testing. Then remove the slab from the mold together with the removable base of the mold (constructed of particle board) before placing on a pallet jack.”

11.7 - Replace with:

“Core or saw the slab, using water as coolant, into the desired specimen shapes as soon as possible. Do not obtain the specimens from the outside edges (50-65 mm) of the slab. The edges are approximately 2 to 2.5 times the nominal size of the aggregate used. Store approximately 3 kg of the wasted mix for the determination of the theoretical maximum specific gravity if desired.”